Generic Detector R&D for an Electron Ion Collider
Committee Meeting 30–31 January 2020

BROOKHAVEN NATIONAL LABORATORY

eRD21 UPDATE: EIC BACKGROUND STUDIES AND THE IMPACT ON THE IR AND DETECTOR

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Jefferson Lab
Exploring the Nature of Matter

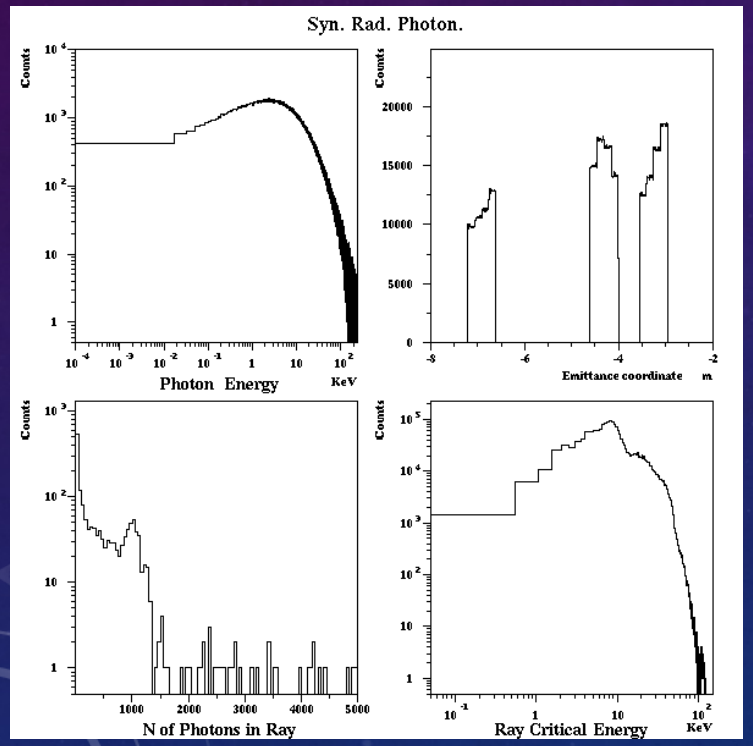
OLD DOMINION UNIVERSITY

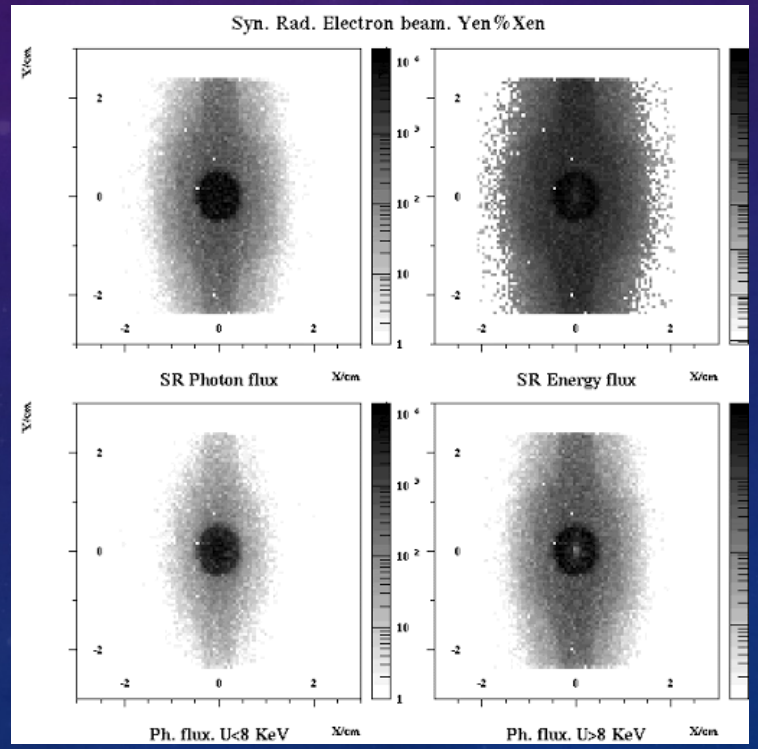
PERSONNEL

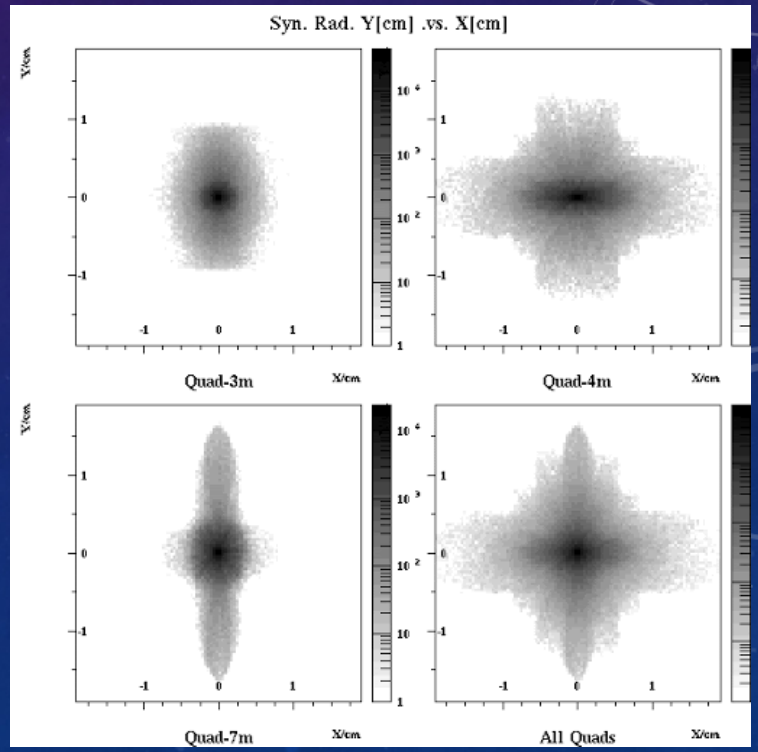
- Funded
  - Vitaly Baturin, PostDoc ODU 50% FTE
  - Andrey Kim, PostDoc UConn 50% FTE
  - Christine Ploen GRA ODU 33% FTE
- Other Personnel
  - Latifa Elouadrhiri: JLab physics, co-P.I.
  - Charles Hyde: ODU physics , co-P.I.
  - Pavel Degtiarenko: JLab RadCon
  - Marcy Stutzman: JLab accelerator
  - Mike Sullivan: SLAC physics
  - Mark Wiseman: JLab engineering
  - Alexander Kiselev, BNL Physics
  - Vasiliy Morozov: JLab accelerator
  - Youri Sharabian: JLab physics
  - Nick Markov: JLab physics
  - Kyungseon Joo: UConn physics
  - Yulia Furletova: JLab physics
  - Frank Marhauser: JLab RF

SYNCHROTRON PHOTON GENERATION

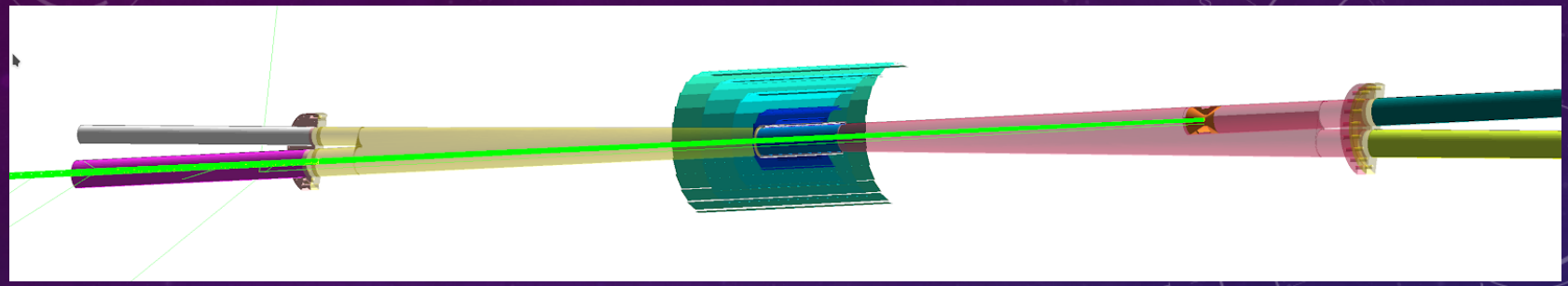
- Semi-analytic code ported from SLAC
- Power Distribution as a function of critical energy turned into ensemble of photons for further propagation by GEANT4.G



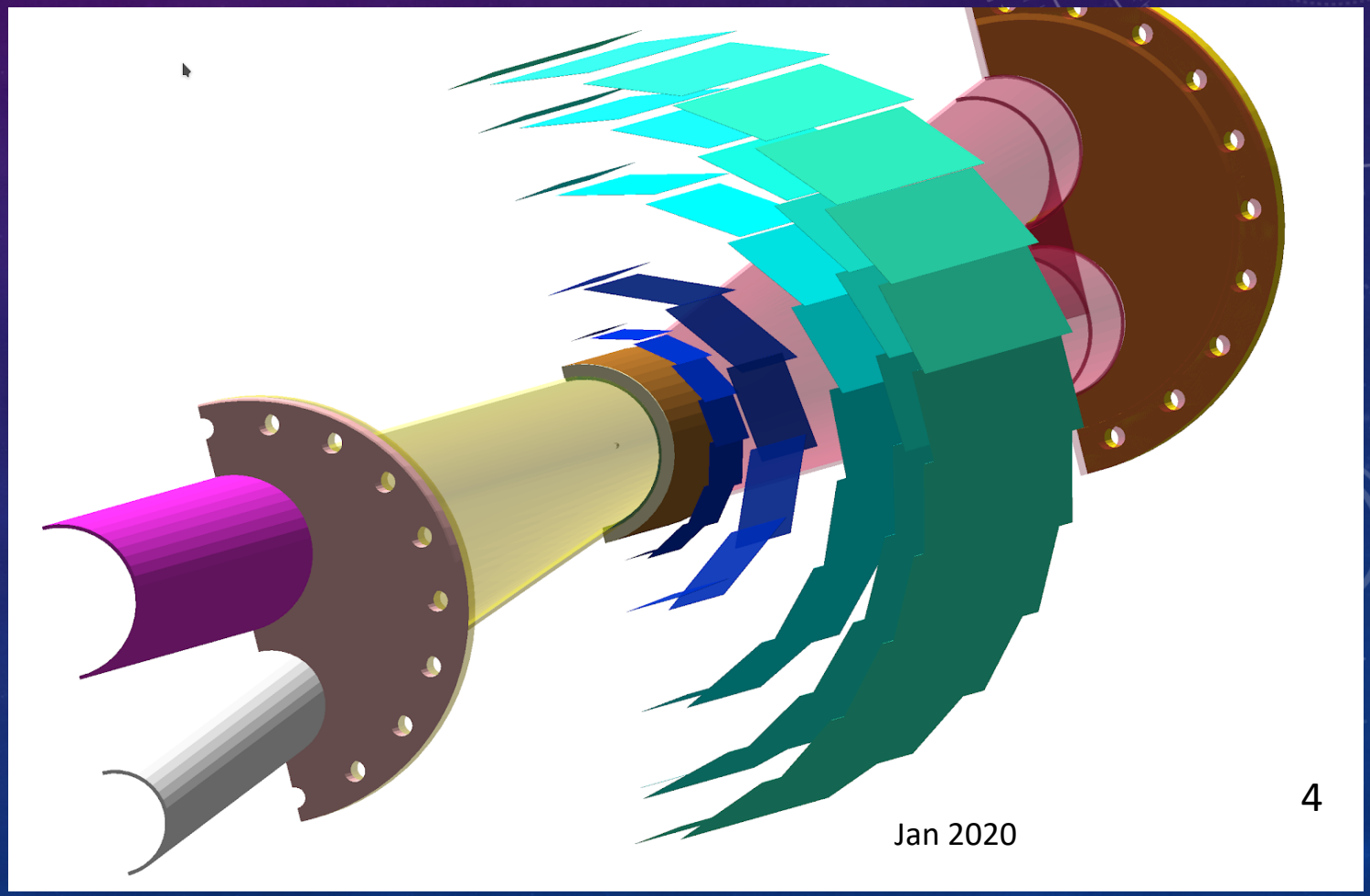




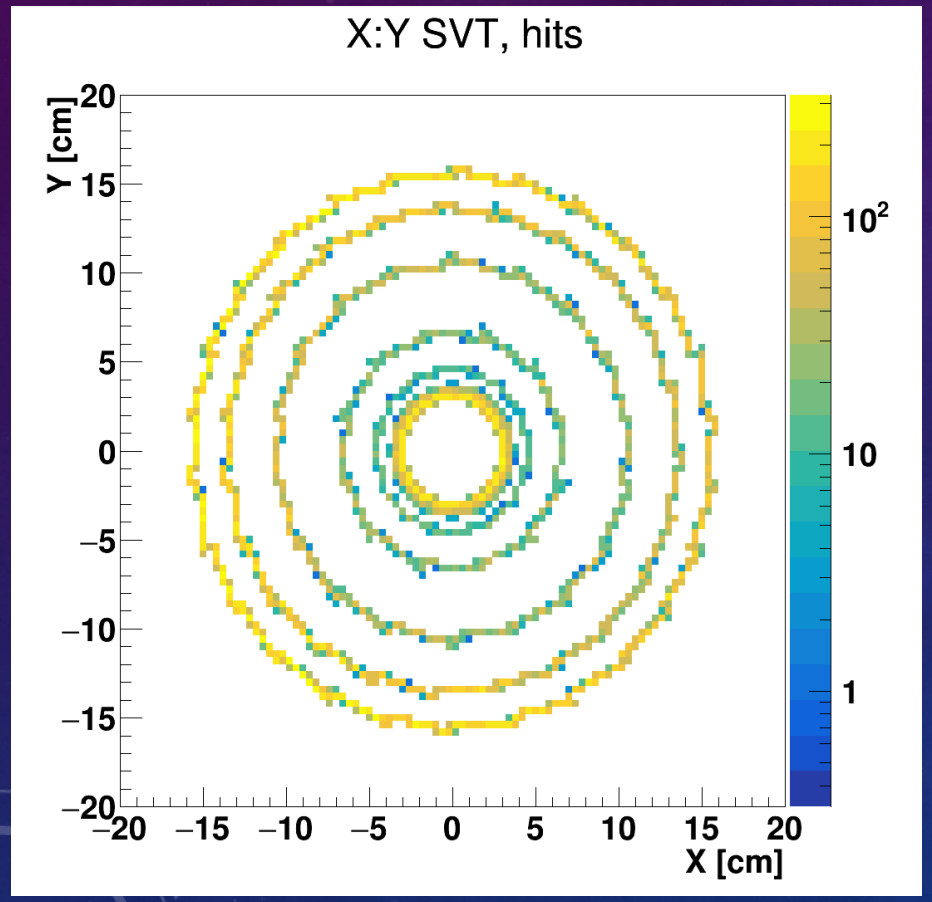
SYNCHROTRON PHOTONS PROPAGATED THROUGH IR

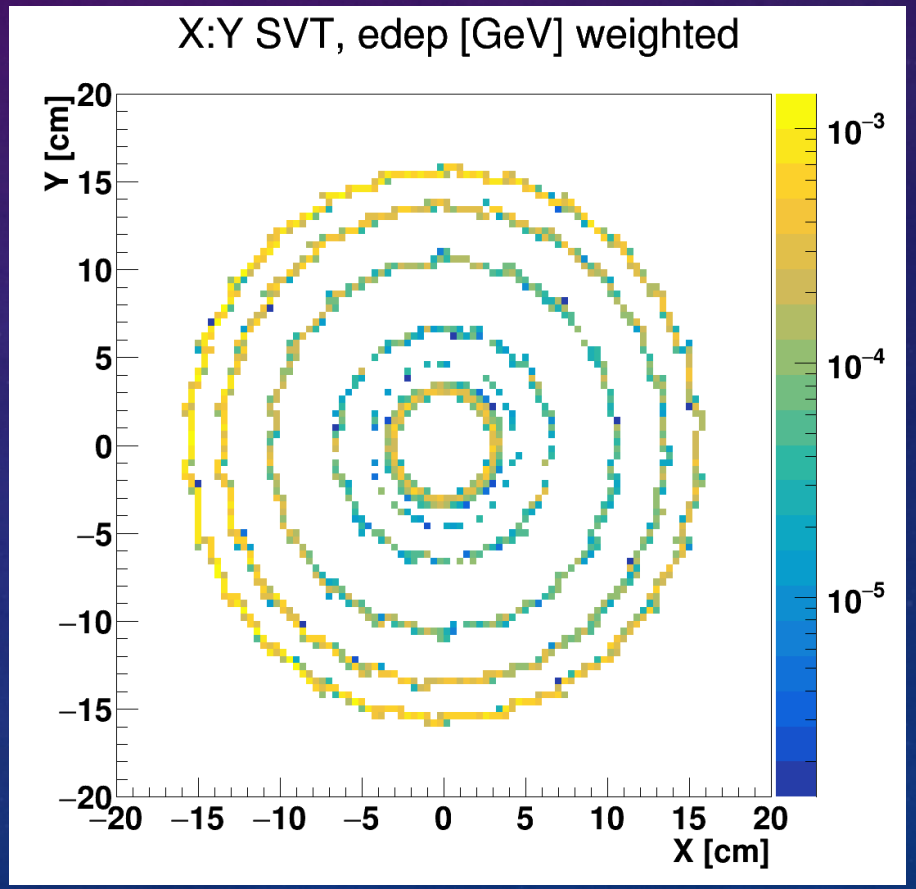


- Central Be Chamber
- 5 layers of Si Vertex Tracker



HITS (left) AND ENERGY DEPOSITION (right)
Be beampipe and 5 Si Layers

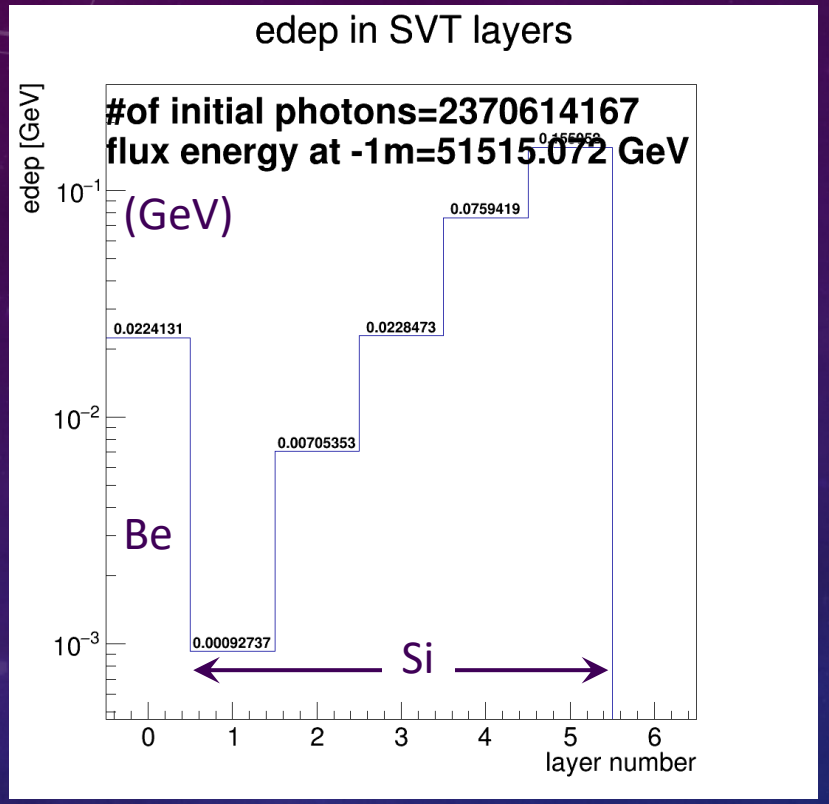


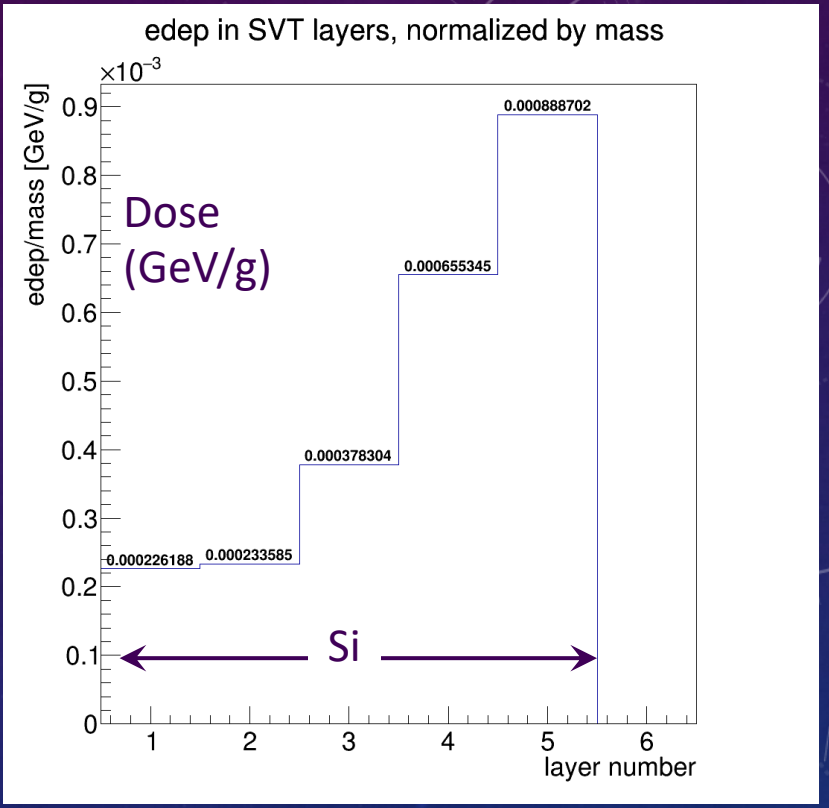


- 10^{11} e^- at 10 GeV
- $2.4 \bullet 10^9$ γ through 2cmΦ collimator at z=1m

ENERGY DEPOSITION (left) and DOSE (right) Be (layer 0) and 5 Si Layers.

- Beam Current 0.8 A
- Total power to 0° = 400 W

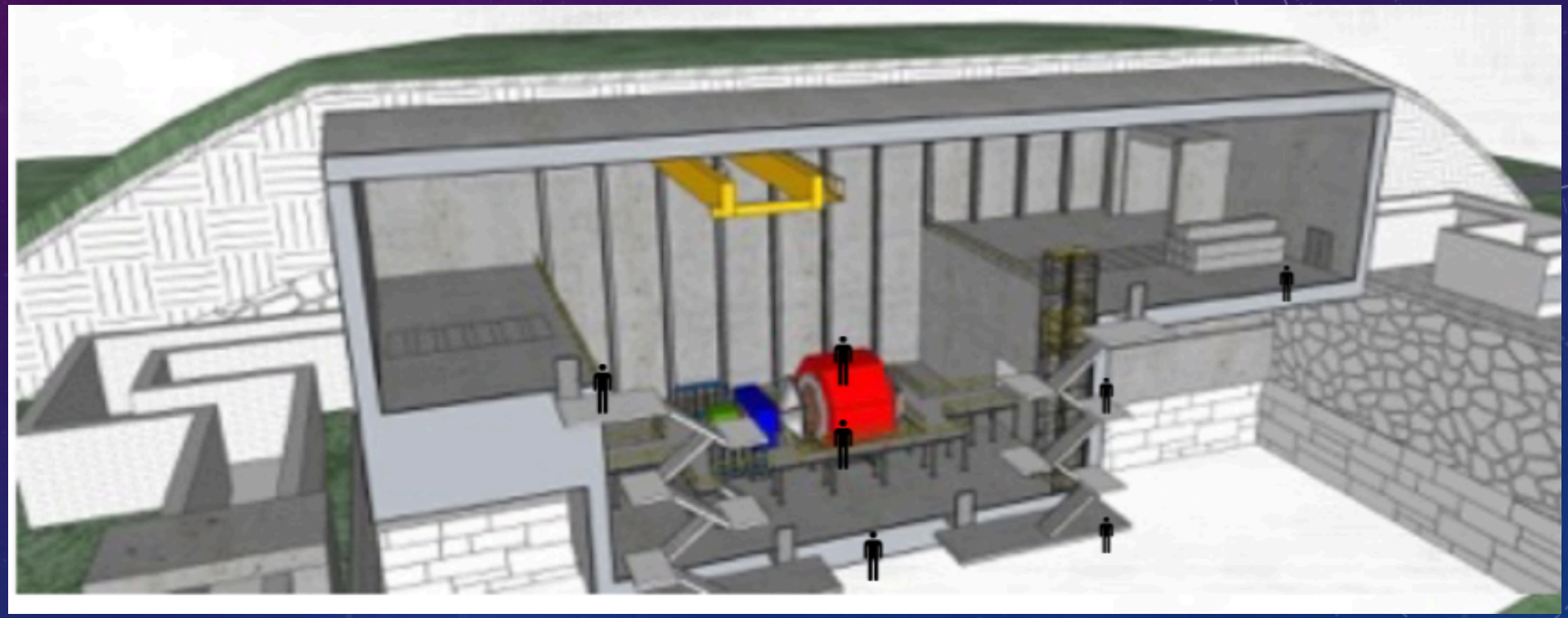




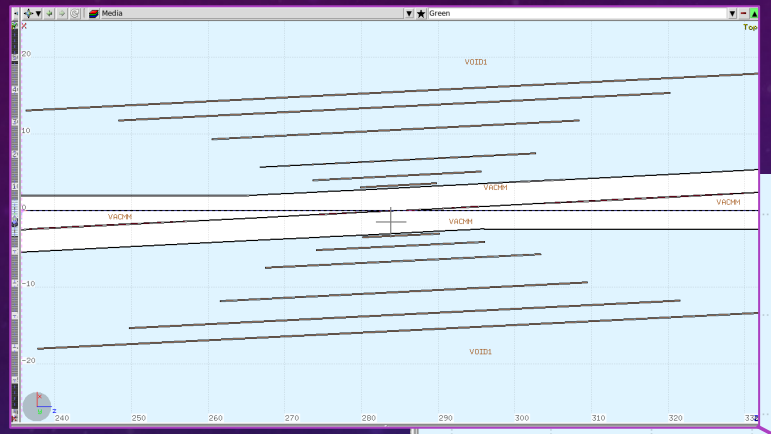
SVT Layer	1	2	3	4	5
Energy Deposition (GeV)	$9.3 \cdot 10^{-4}$	$7.1 \cdot 10^{-3}$	$2.3 \cdot 10^{-2}$	$7.6 \cdot 10^{-2}$	$1.6 \cdot 10^{-1}$
Mass (g)	4.1	30.2	60.4	115.9	174.5
Dose rate (GeV/g/sec)	$1.1 \cdot 10^{4}$	$1.2 \cdot 10^{4}$	$1.9 \cdot 10^{3}$	$3.2 \cdot 10^{4}$	$4.5 \cdot 10^{4}$
Dose rate (KGray/year)	17.7	18.4	29.8	51.3	71.7

BEAM-GAS SIMULATIONS WITH FLUKA

- Full inclusion of 70 m upstream beamline
- Magnets
- Tunnel walls, ceiling, floor



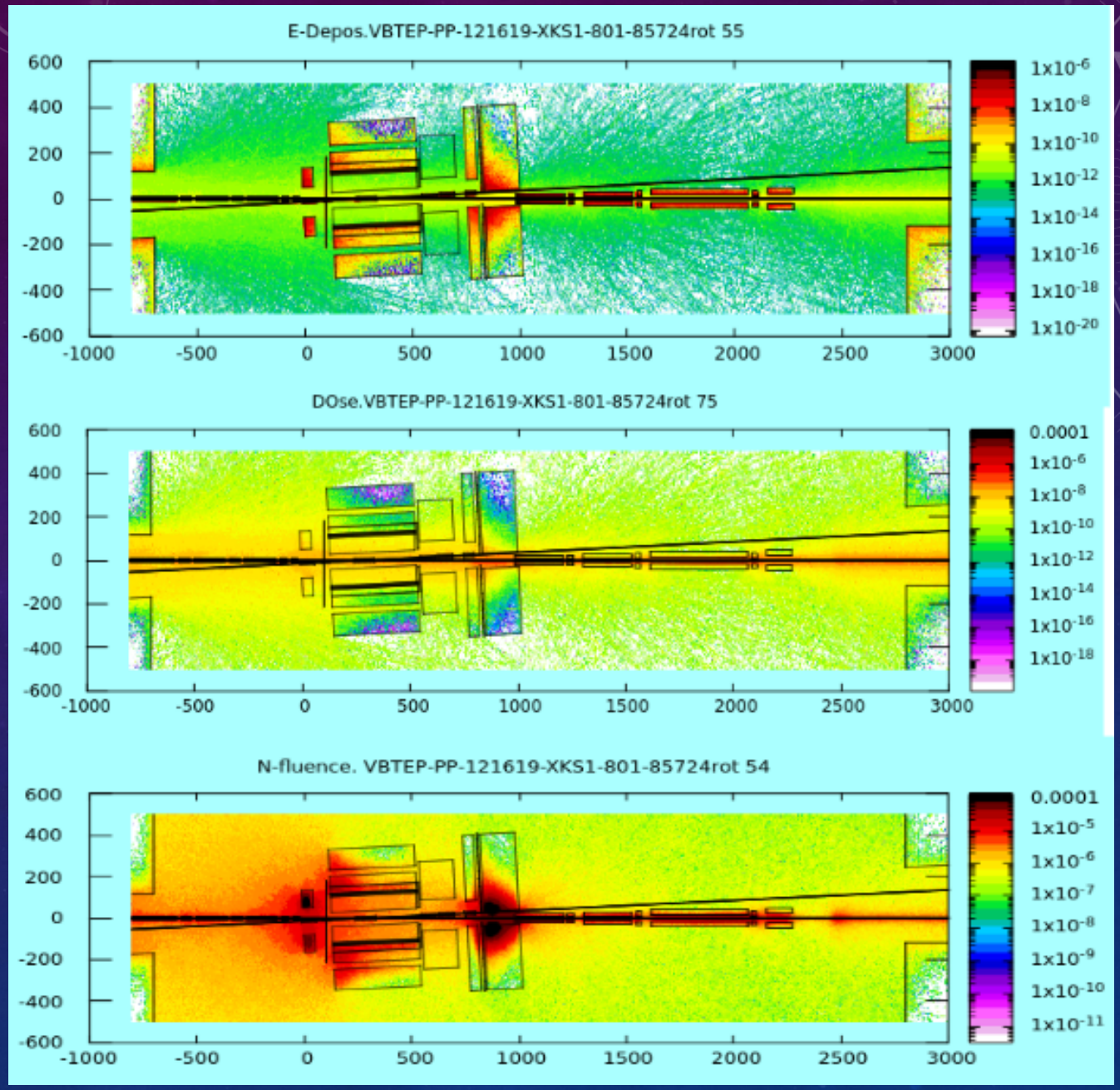
DETECTOR WITH 6 LAYERS OF Si VERTEX TRACKER



- Updated FLUKA Model
- Starting now on eRHIC, design

BEAM-GAS

- Raw Image:
  - Yields per incident proton on 100 mBar gas
  - Multiply by $4.7 \cdot 10^{7}$/s to obtain rates per sec for 0.75A protons incident on 10^{-9} mBar residual gas



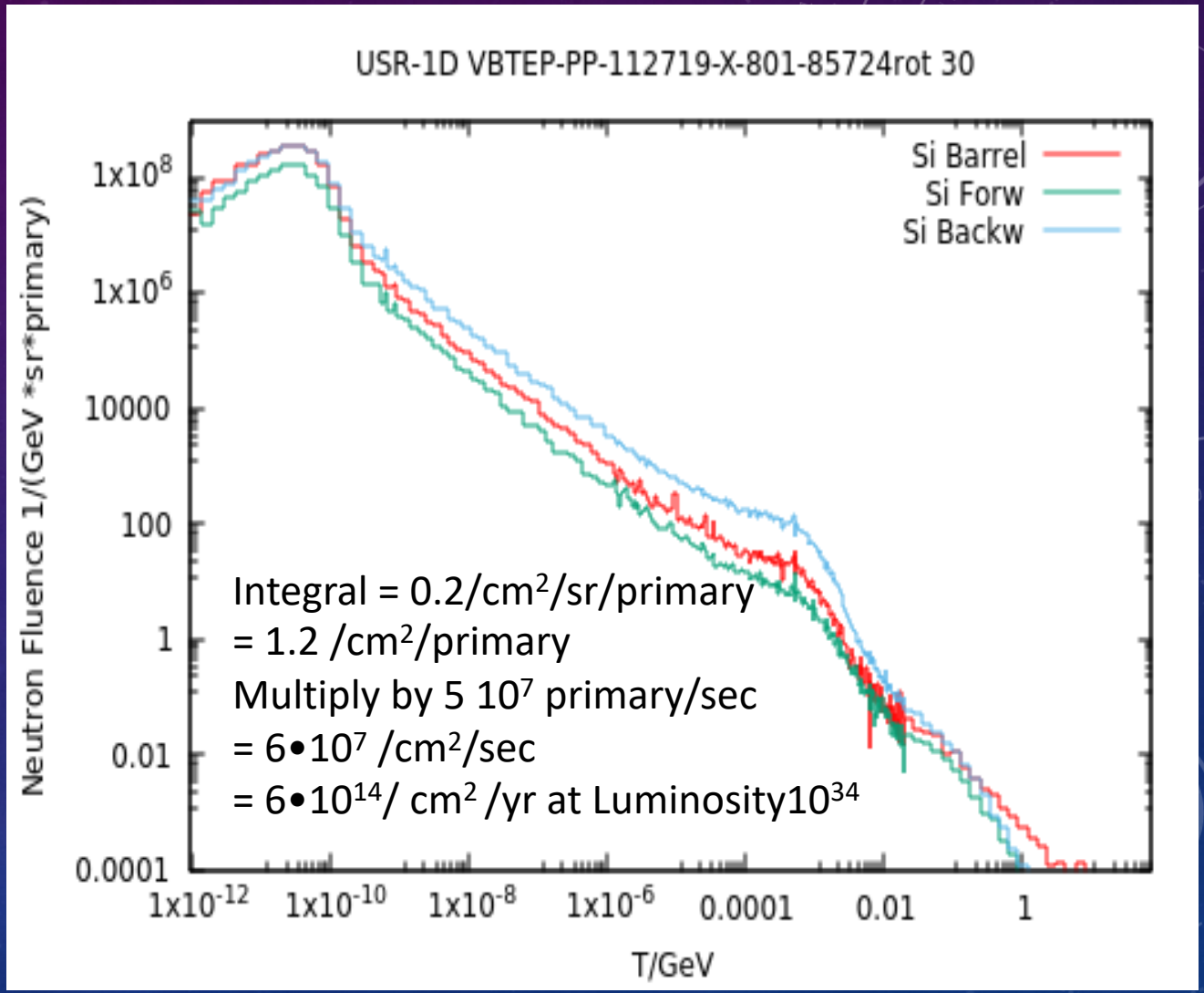
Energy Deposition (GeV/cm^3)

Dose (GeV/g)

Fluence (Particles/ cm^2/sr)

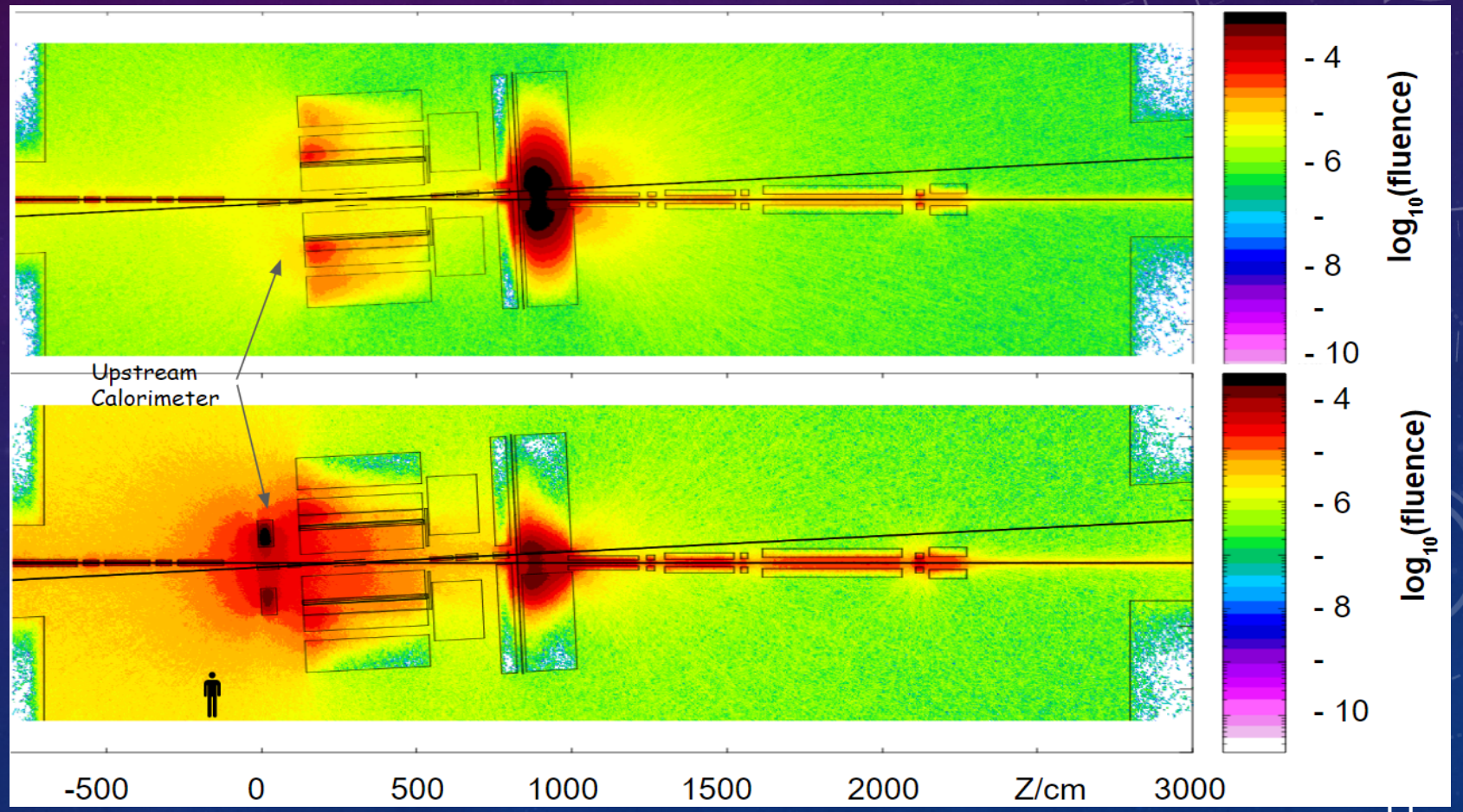
NEUTRON FLUENCE AT THREE LOCATIONS

- "Si Barrel"= SVT
- Si Forward = photo-sensors at *z = 2.4m, r = 1m*
- Si Backward = photo-sensors at z=–1.6m, r=1m



THE DETECTOR IS BOTH AN ABSORBER AND A GENERATOR OF BACKGROUND

- The electron side calorimeter increases the upstream flux and decreases the downstream flux



JLEIC NEUTRON BACKGROUND SIMULATIONS ADDITIONAL PROGRESS SINCE 01-JAN-2020

- MARS
  - MARS installed on JLab cluster
  - Vitaly Baturin subscribed as MARS user
  - N. Mokhov (FNAL), P.Degtiarenko (JLab) will install advanced MARS version with graphical interface in February
- FLUKA
  - New FLUKA version (including ep collisions) installed, simulations started
  - Initial studies done with detector solenoid field: no effect on backgrounds
    - Calculated backgrounds dominated by neutrons.

OUTLOOK

- Migrate simulation models to eRHIC beamlines & detectors
  - Will need full physical data on locations, strengths of magnets in full Interaction Region
  - Approximate iron content of magnet yokes
  - Vitaly Baturin will come to BNL later in Spring

TIME/RESOURCES TO COMPLETION

- Path to TDR 2023
- BNL Interaction Region: Synchrotron, Beam-Gas, Beam-Beam
  - FY 2020 + FY 2021
- Funding FY 2020

  50% postdoc ODU

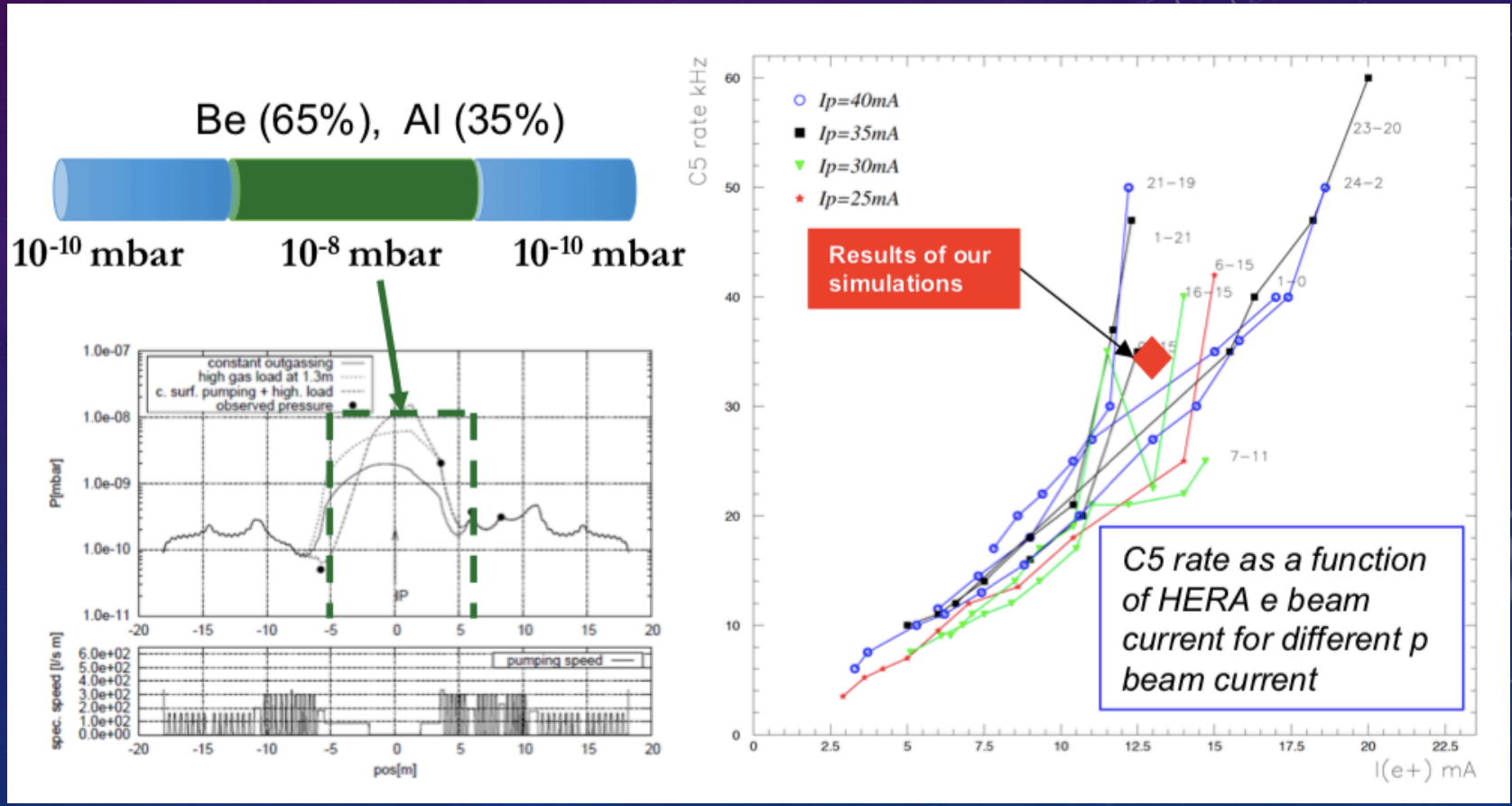
  50% postdoc Uconn

  25% Grad
- Expected Funding Request FY 2021 to complete project
  - 1.5 FTE Postdoc
  - 1 FTE Grad Student
  - Consultant funding (Mike Sullivan)
  - Engagement with BNL & JLab Engineering, (Mechanical & Vacuum), Collider Accelerator Division

BACKUP

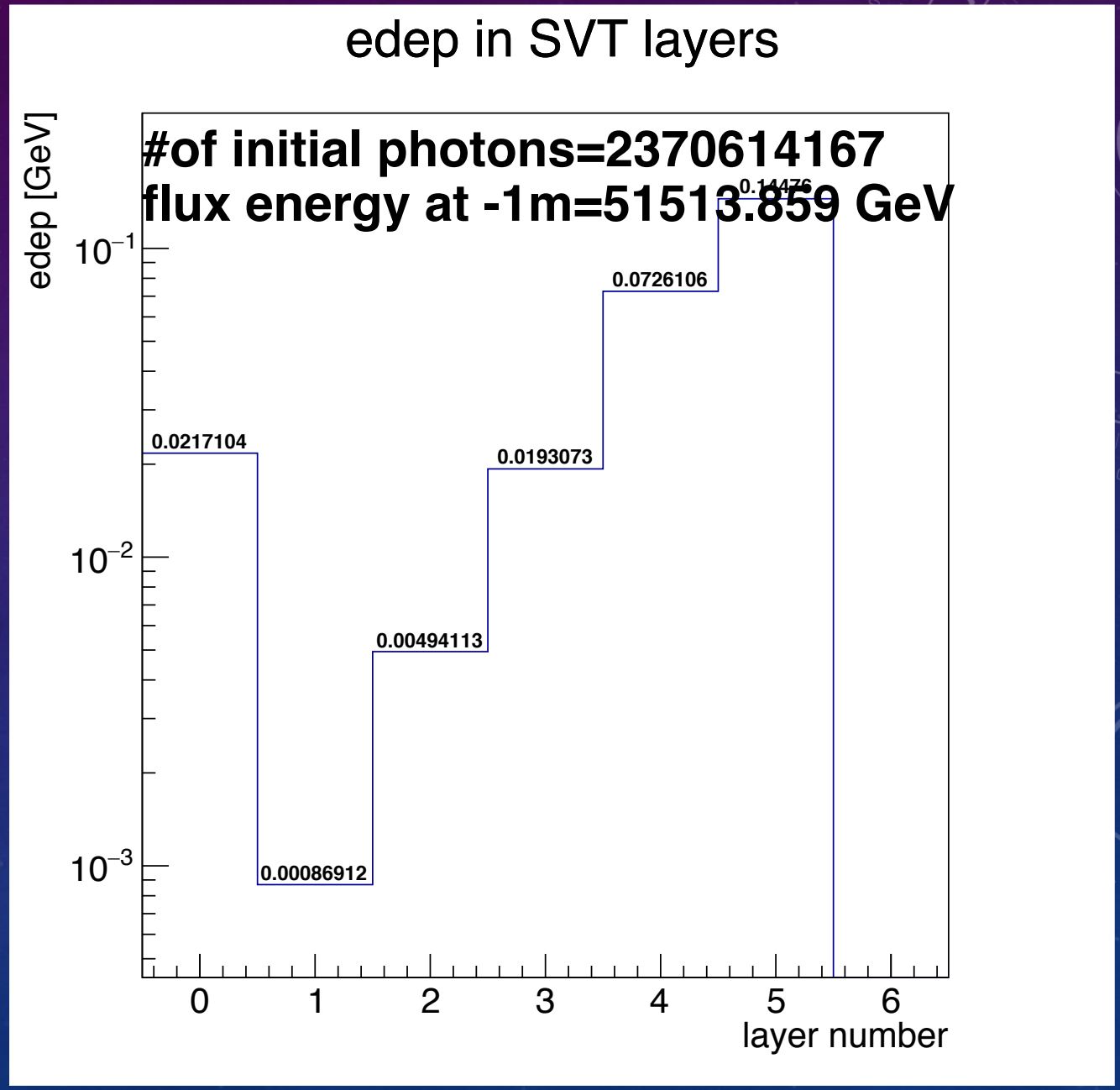
CALIBRATING BEAM-GAS INTERACTION BACKGROUNDS TO HERA DATA

- GEANT4 simulations (red diamond) agree well with HERA measurements



SYCHROTRON HITS IN SVT WITH UPSTREAM AL BEAMPIPE REPLACED WITH STAINLESS STEEL

- Only ~10% decrease in hits to SVT compared with slide 6



SYNCHROTRON HITS IN SVT AND ENTIRE BEAMPIPE
(FLANGE-TO-FLANGE)